*European Journal of Orthodontics* 10 (1988) 30–38



# Evaluation of the risk of root resorption during orthodontic treatment: A study of upper incisors

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SUMMARY The purpose of the study was to investigate the risk of severe apical root resorption after orthodontic treatment with fixed appliances in relation to resorption after initial treatment, 6–9 months; and in relation to apical root form. The risk of severe apical root resorption in relation to resorption after 6–9 months of treatment was studied on 390 upper incisors in 98 consecutive patients (55 boys, 43 girls). Intra-oral radiographs before treatment, after 6–9 months and after treatment were evaluated. The importance of the root form (normal, short, blunt, apically bent, pipette shaped) for root resorption was studied on 610 upper incisors in 153 patients (75 boys, 78 girls). Intra-oral radiographs before and after treatment were evaluated. Treatment was performed with an edgewise or a Begg technique and lasted from 11 to 29 months. An index from 0 to 4 (Fig. 1) was used for the evaluation of the degree of root resorption.

Root resorption after treatment was significantly related to the resorption after the initial 6–9 months. The results indicate a risk of severe resorption in teeth with minor resorptions after 6–9 months. Even an irregular root contour after 6–9 months indicates a risk of severe resorption. No-severe resorption was found after treatment in teeth without resorption after 6–9 months. The degree of root resorption in teeth with blunt or pipette shaped roots was significantly higher than in teeth with a normal root form.



## Introduction

Histological and radiographic observations have shown that root resorption is a frequent consequence of orthodontic treatment (Reitan, 1974; Rygh, 1977; Harry and Sims, 1982). In most patients this resorption is minor and of no importance. A few teeth however exhibit severe resorption. In a study by Goldson and Henrikson (1975) it was found that 6 per cent of 924 teeth were resorbed more than 2 mm after treatment with a Begg appliance and Malmgren *et al.* (1982) found a similar degree of root resorption in 10 per cent of 264 incisors treated with an edgewise appliance and in 5 per cent of 176 incisors treated with a Begg appliance.

There is no single explanation why certain teeth resorb severely, but a number of factors taken together may explain why resorption takes place. In the literature some risk factors are mentioned: deviating root form (Oppenheim, 1942; Newman, 1975), treatment with torque and uprighting springs (Goldson and Henrikson, 1975) and treatment with Class II elastics or rectangular archwires for a long period (Linge and Linge, 1983). In a study by Malmgren *et al.* (1982) traumatized teeth with signs of root resorption prior to orthodontic treatment were found to be more prone to root resorption during treatment.

In order to identify cases in which there is an increased risk of substantial root resorption, a periodic radiographic control during active orthodontic treatment has been recommended (Newman, 1975; Brown, 1982). Hollender *et al.* (1980) have proposed a limited radiographic examination every three months during treatment. However, no clinical report on this has been presented. In order to reduce the radiographic dosage and cost, the number of controls should be kept to a minimum.

The aim of this study was to test whether it is possible to estimate the risk of severe root resorption at an early stage in orthodontic treatment; and to evaluate the importance of the root form for root resorption.

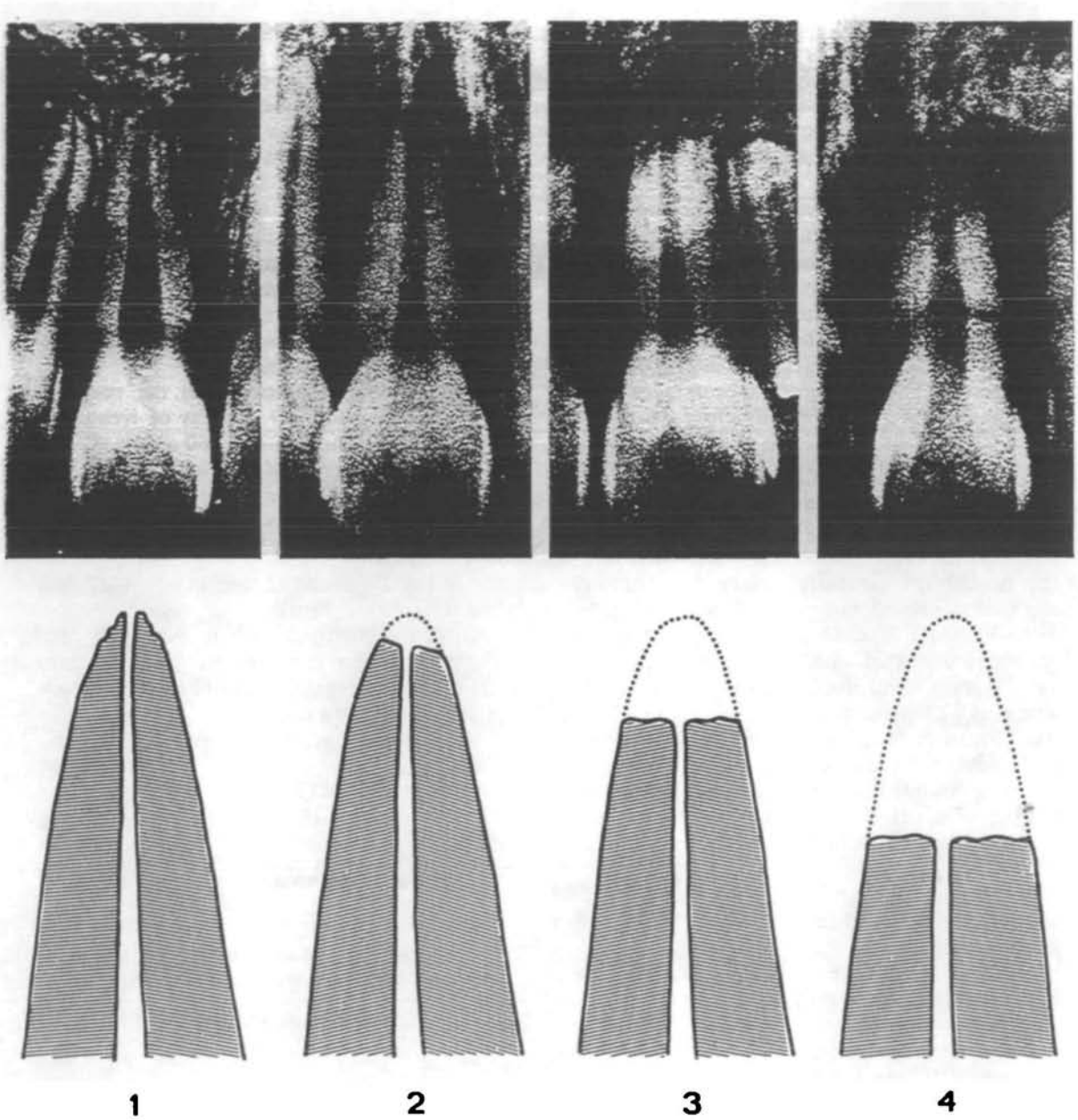


**Figure 1** Root resorption index for quantitative assessment of root resorption. 1, Irregular root contour. 2, Root resorption apically, amounting to less than 2 mm. Minor resorption. 3, Root resorption apically, from 2 mm to one third of the original root length. Severe resorption. 4, Root resorption exceeding one third of the original root length. Extreme resorption.

## Subjects and methods

98 consecutive patients (55 boys, 43 girls), mean age 15 years (range 12 to 17 years) were included in this study. The patients had different types of malocclusions: 44 with Angle Class I, 52 with Angle Class II and 2 with Angle Class III deviations. Treatment was performed with extraction in 72 patients and without extraction in 26 patients. In 49 patients an edgewise appliance was used and a Begg appliance in the remaining 49. Treatment lasted from 11 to 29 months (mean, 19 months) in the edgewise group and from 10 to 32 months (mean, 20 months) in the Begg group. The radiographic examinations in these patients were performed before treatment, after 6-9 months and at the end of treatment. A total of 390 teeth was evaluated.

Evaluation of the importance of the root form for root resorption was performed on the same subjects and in addition on 55 consecutive patients described in an earlier study (Malmgren *et al.*, 1982). The 55 patients (20 boys, 35 girls) with the mean age 14 years (range 11 to 17 years) were treated with extraction of first premolars and a fixed appliance (33 with an edgewise and 22 with a Begg appliance). Treatment lasted from 12 to 22 months (mean, 19 months) in the edgewise group and from 13 to 28 months (mean, 21 months) in the Begg group. Intra-oral radiographs before and after treatment were examined in these patients. A total of 610 apices was evaluated.

Treatment resulted in good parallelism of teeth and good axial inclination of the incisors in all patients.

The radiographic examination included the four upper incisors and was performed with a modified parallel technique and long focus film distance (roentgen cone 20 mm). Orthoradial inclination to the teeth was striven for. Each incisor was evaluated on at least two radiographs. Signs of root resorption were registered with index scores from 0-4 (Fig. 1) in the same way as was reported earlier (Malmgren *et al.*, 1982). In order to standardize the method 15 patients from the earlier study, randomly selected, were evaluated and good agreement with earlier registrations was found. This material was used as a reference for the further evaluation of index scores.

The form of the roots was evaluated as: normal (n = 387), short (n = 56), blunt (n = 74), bent with an apical bend (n = 79) and pipette formed (n = 14) (Fig. 2).

The risk of severe root resorption is described as: minimal, slight, moderate or high if the percentage of roots in a group with such resorptions was: 0%, 0-25%, 25-50% and > 50%.

The reproducibility of the evaluation of root resorption was studied with double determinations on 15 randomly selected patients. Radiographs from before treatment, after 6-9 months and after treatment were used. Signs of root resorption after 6-9 months and after treatment were evaluated. In all, duplicate determinations of 120 apices were performed.

Duplicate determinations with the root resorption index after 6-9 months of treatment showed full agreement in 48 of 60 apices (80 per cent) and a difference of one index score was found in 12 apices (20 per cent). After treatment the corresponding duplicate determinations showed full agreement in 51 of 60 apices (85 per cent) and a difference of one index score was found in 9 (15 per cent).

Statistical comparisons of the degree of root resorption between different groups of teeth in terms of root resorption indices have been made using the chi-square test.

The variables used in the analyses are: Age, sex, root form, treatment time with rectangular archwires (range 0-15 months), with torquing auxiliaries (range 0-12 months), with uprighting springs (range 0-6 months), with Class II elastics (range 0-27 months) and total treatment time.

**Table 1** Frequency of root resorption after treatment in relation to resorption after 6-9 months.

| Resorption after 6-9 months | Resorption after treatment Index* | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | Sum |
| Index* | | | | | | |
| 0 | 49 | 34 | 30 | 0 | 0 | 113 |
| 1 | — | 48 | 78 | 17 | 0 | 143 |
| 2 | — | — | 80 | 48 | 1 | 129 |
| 3 | — | — | — | 1 | 4 | 5 |
| Sum | 49 | 82 | 188 | 66 | 5 | 390 |

* Index 0 no resorption
1 irregular root contour
2 minor resorption
3 severe resorption
4 extreme resorption

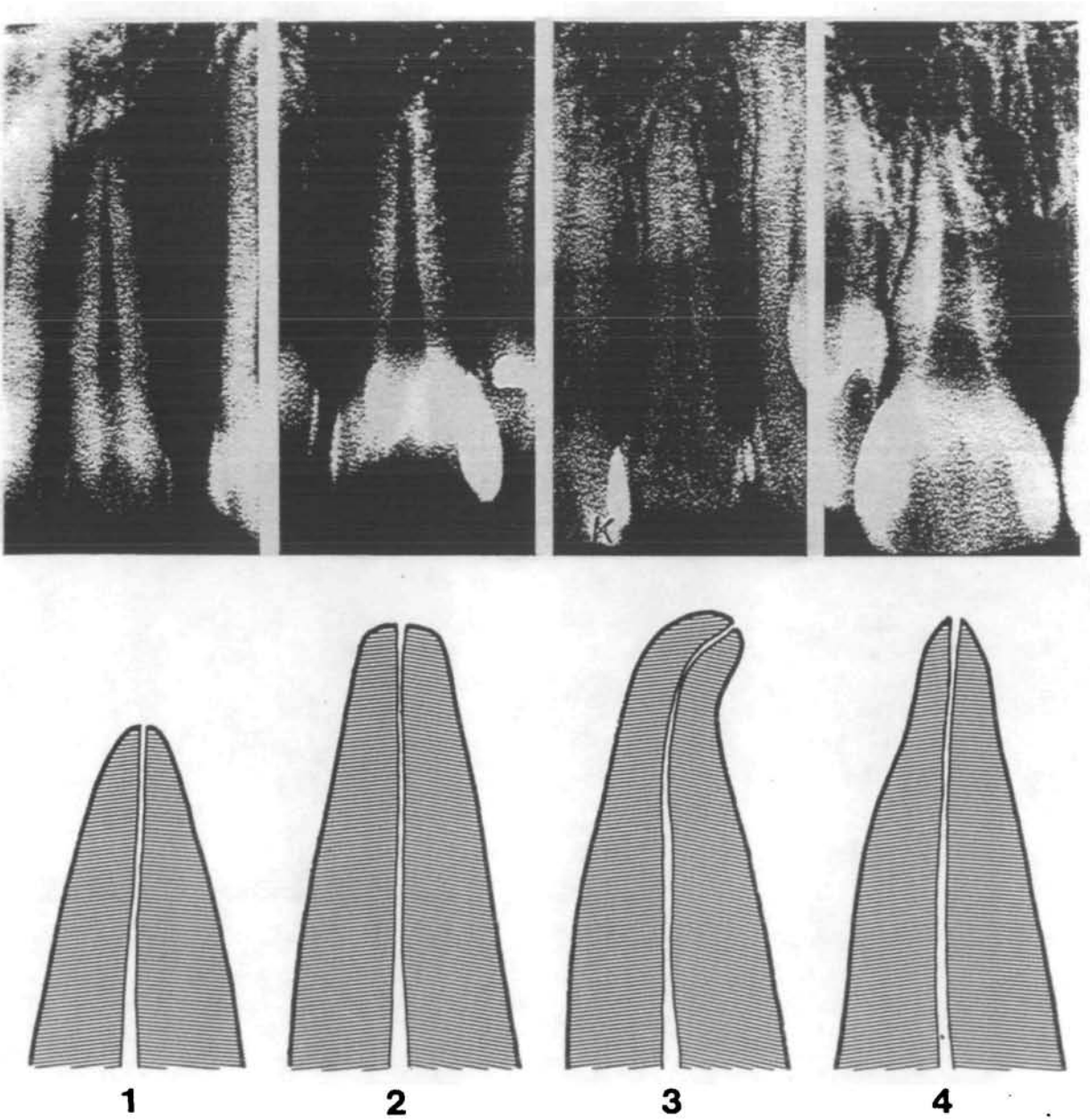


Figure 2 Deviating root forms. 1, Short root. 2, Blunt root. 3, Root with apical bend. 4, Root with apical pipette shape.

## Results

**Root resorption in relation to initial resorption (n = 390), Table 1.** After 6-9 months of treatment a great variation in root resorption was found. No resorption or only an irregular root contour was found in 256 teeth (66 per cent), resorption was minor in 129 teeth (33 per cent) and severe in 5 teeth (1 per cent). After treatment no resorption or only an irregular root contour was found in 131 teeth (34 per cent), resorption was minor in 188 teeth (48 per cent), severe in 66 teeth (17 per cent) and extreme in 5 (1 per cent).

Severe resorption after treatment was not

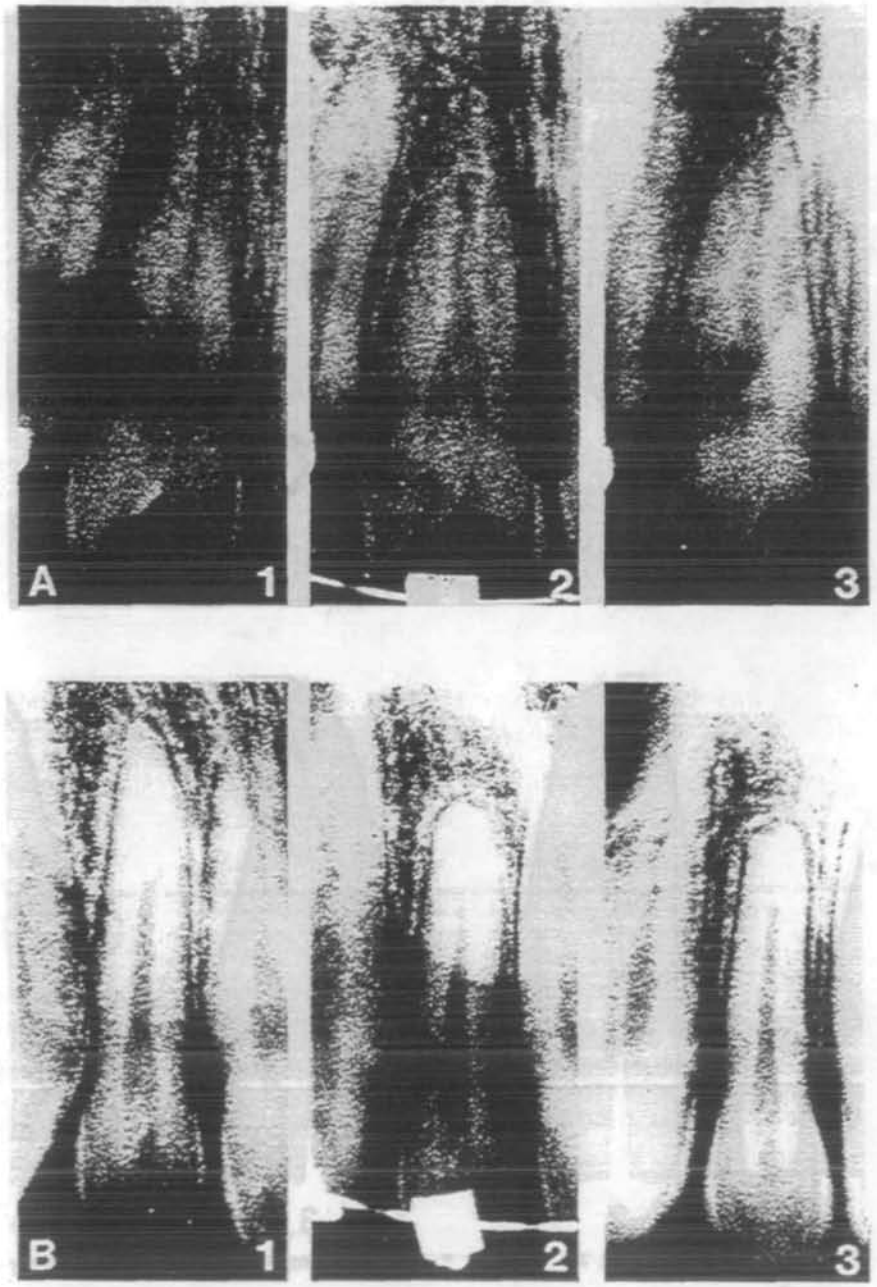


**Figure 3** Root resorption after treatment in relation to initial resorption after 6-9 months. **A:1,** Before treatment; **A:2,** No resorption after 6-9 months; **A:3,** A minor resorption after treatment. **B:1,** Before treatment; **B:2,** A minor resorption after 6-9 months; **B:3,** A severe resorption after treatment.

found in any teeth without resorption after 6-9 months. In teeth with an irregular root contour after initial treatment, 17 (12 per cent) of 143 teeth showed severe resorption at the end of treatment and in teeth with minor resorption after initial treatment, 49 (38 per cent) of 129 teeth showed severe resorption (Fig. 3). The number of teeth with severe resorption after

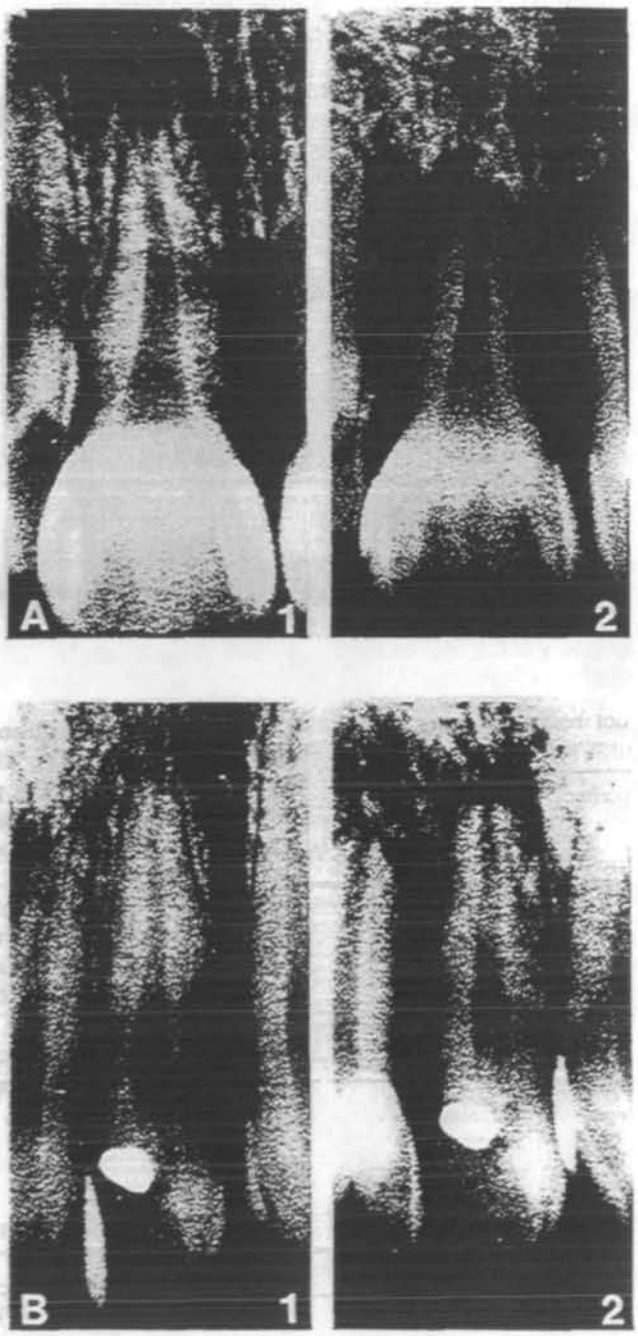


**Figure 4** Typical effect of root resorption. **A**, a pipette shaped root (1) before and (2) after treatment. **B**, A blunt root (1) before and (2) after treatment. **C**, A root with apical bend (1) before and (2) after treatment.

treatment was significantly higher in teeth with minor resorptions or in teeth with an irregular root contour after initial treatment than in teeth without such initial resorption ($P < 0.001$). Extreme resorption was registered in one of 129 teeth with minor resorption after initial treatment and in 4 (80 per cent) of 5 teeth with severe resorption after initial treatment.

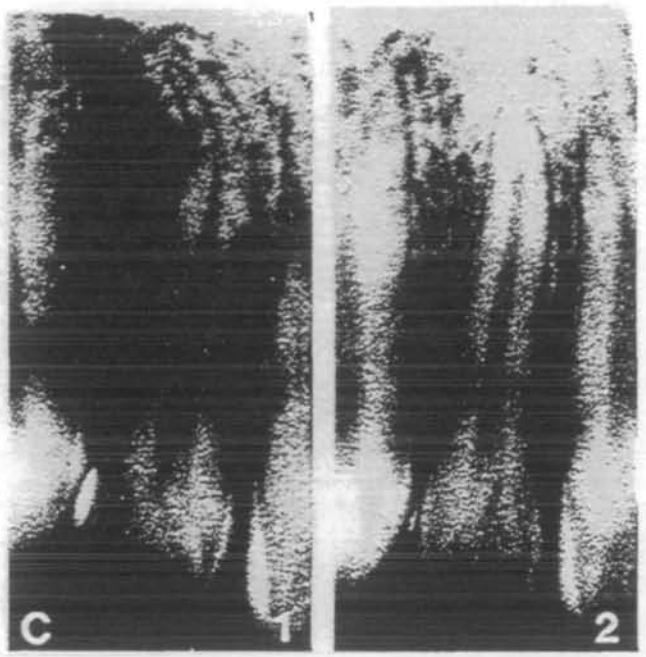


Table 2 Frequency of root resorption after treatment in relation to root form and sex.

| Root form | Resorption after treatment Index* 0 | 1 | 2 | 3 | 4 | Sum |
|---|---|---|---|---|---|---|
| Normal | 70 | 99 | 167 | 48 | 3 | 387 |
| Short | 2 | 6 | 36 | 12 | 0 | 56 |
| Blunt | 4 | 10 | 31 | 27 | 2 | 74 |
| Apically bent | 6 | 9 | 45 | 19 | 0 | 79 |
| Pipette shaped | 0 | 0 | 3 | 11 | 0 | 14 |
| Boys | 30 | 56 | 129 | 41 | 0 | 256 |
| Girls | 52 | 68 | 153 | 76 | 5 | 354 |

* Index 0 no resorption
1 irregular root contour
2 minor resorption
3 severe resorption
4 extreme resorption

**Root resorption in relation to root form (n = 610)**
**Table 2.** The degree of root resorption in teeth with blunt or pipette shaped roots was significantly higher than in teeth with normal root form ($P < 0.001$). An almost significant difference in the degree of root resorption was found in teeth with apical bends ($P < 0.05$). No such difference was found in teeth with short roots. The typical effect in blunt, pipette shaped roots and roots with apical bends is shown in Fig. 4.

Severe root resorption was more frequent among girls than boys; 81 (23 per cent) of 354 teeth in girls and 41 (16 per cent) of 256 teeth in boys were severely resorbed. The difference was almost significant ($P < 0.05$).

The variables age, treatment time and time with Class II elastics, torquing auxiliaries, uprighting springs and rectangular archwires were not significantly related to the amount of root resorption. There was no significant difference in the degree of root resorption between the patients treated with an edgewise and those with a Begg appliance.

## Discussion

Earlier studies have shown that there is a high frequency of apical root resorption in upper incisors (Phillips, 1955; De Shields, 1969; Goldson and Henrikson, 1975). The importance of various factors for root resorption have therefore been studied in these teeth.

The risk of severe root resorption in teeth with resorption after the initial 6-9 months is in accordance with the results of a study by Goldson and Henrikson (1975). Loss of root length has been observed after intrusion of teeth within 35 days in a scanning electron microscope study

(Harry and Sims, 1982), but clinically there is a marked variation in time when root resorption can be observed (Linge and Linge, 1980). In a study of apical root resorption of upper incisors caused by intrusive tooth movement, Dermaut and De Munck (1986) used a follow-up period of 29 weeks. Linge and Linge (1983) found only a minor risk of root resorption in patients treated for less than 9 months but a significantly higher risk in patients treated for longer periods. A radiographic control of the tendency for root resorption after 6-9 months would therefore seem reasonable.

Severe resorption at the control was found in 5 teeth, 4 of which became more resorbed during the following treatment. The number of teeth in this group is too small for a statistical evaluation, but the risk of further resorption in teeth with severe resorption after 6-9 months seems high. A minor resorption at the control indicates a moderate risk; and an irregular root contour indicates a small risk of severe resorption. If no resorption is found, the risk of further resorption is minimal. The root form most susceptible to severe root resorption was pipette shaped. The biconcave form means that the apical part is thin and even minor resorption has a great effect on root length.

A moderate risk of severe resorption was found in blunt roots. The aetiology of this root form might be a disturbance during the development of the root or an earlier superficial resorption caused by trauma or non physiological forces such as nailbiting acting on the tooth. Linge and Linge (1983) found a relation between trauma and severe resorption during orthodontic treatment. Odenrick and Brattström (1983) found a higher degree of apical root resorption before and after treatment among nailbiters.

The typical resorption of teeth with apical bends involved the bent part of the root. The risk for further resorption was minimal. Short roots did not exhibit severe resorption more frequently than did normal roots. The consequence of even a minor resorption in such teeth might, however, be unacceptable.

The frequency of severe root resorption was higher among girls than boys, but the difference was small. Massler and Perreault (1954) registered more idiopathic root resorption in girls. Many reports on idiopathic resorption in teeth concern exclusively females (Carr, 1958; Hopkins and Adams, 1979; George and Miller, 1986) but previous reports of the relation between root resorption and orthodontic treatment have not shown a difference between the sexes.

Few investigations have been published which compare root resorption in different treatment techniques, but many studies concern the importance of various orthodontics forces. The risk of apical root resorption has been reported to increase in connection with root-torquing and uprighting auxiliaries (Goldson and Henrikson, 1975), Class II elastics and rectangular archwires (Linge and Linge, 1983). In the present study, differences in the amount of root resorption could not be related to the use of such forces nor to the type of appliance used. This is in accordance with Malmgren *et al.* (1982) who found no significant difference in apical root resorption in 261 incisors treated with an edgewise appliance and 176 incisors treated with a Begg appliance. A positive correlation between the banding time, the patients age and apical root resorption has been found by Linge and Linge (1983). They registered more resorption in patients starting treatment after 11 years of age when root development is completed and in patients treated for more than 9 months with fixed appliances. No such relationship was found in the present study. All patients started treatment after the age of 11 years and there were no great differences in banding time. Only a few patients were treated for less than a year.

## Conclusions

The importance of a radiographic control after 6-9 months of treatment with a fixed appliance is analysed. Severe resorption found at that time seems to indicate a high risk of extreme resorption, a minor resorption indicates a moderate risk and an irregular root contour gives a small risk of severe resorption at the end of treatment. There is a high risk of severe resorption in teeth with pipette shaped roots and a moderate risk for teeth with blunt roots.

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